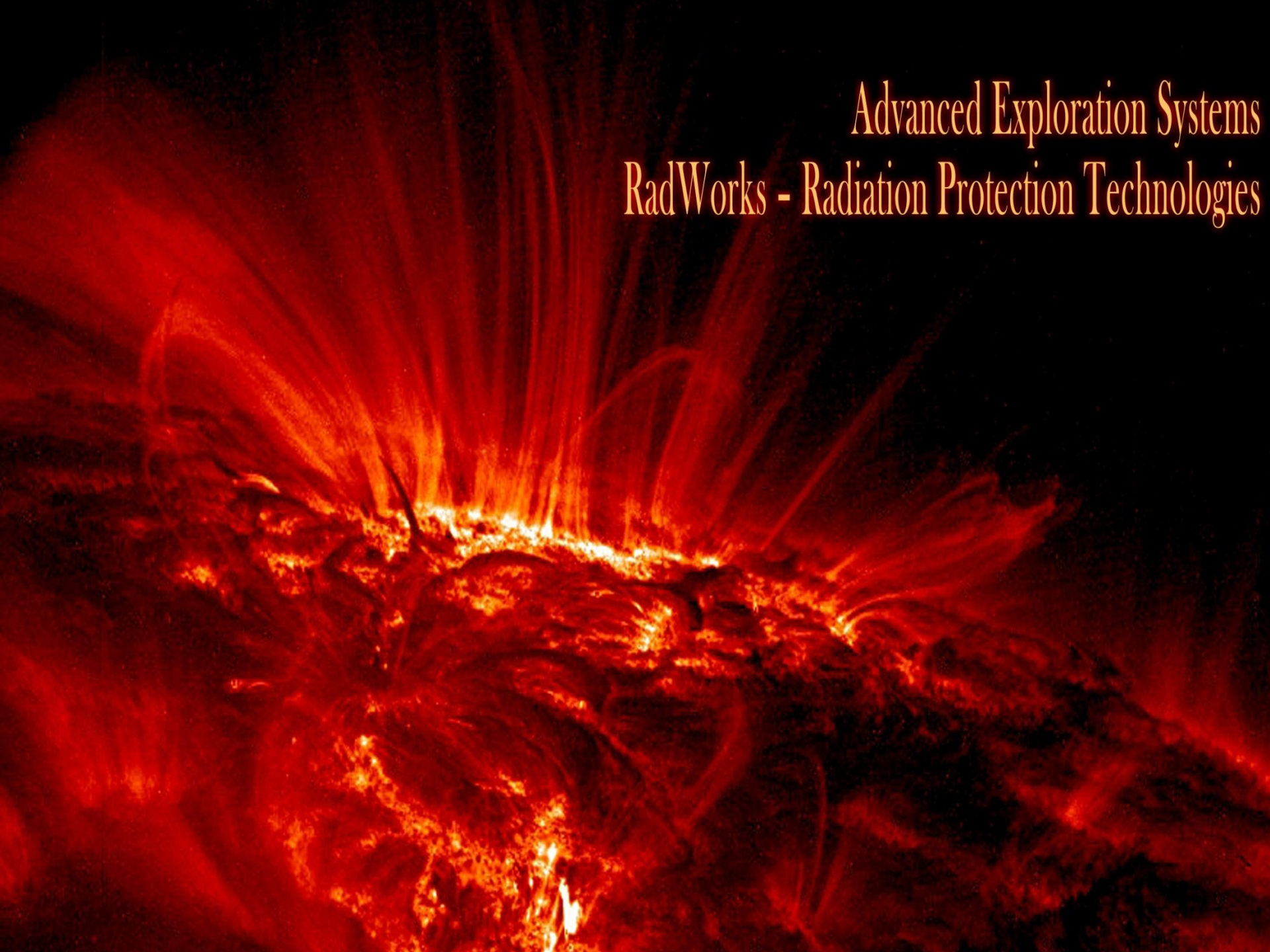

Advanced Exploration Systems
RadWorks - Radiation Protection Technologies

Advanced Neutron Spectrometer (ANS)

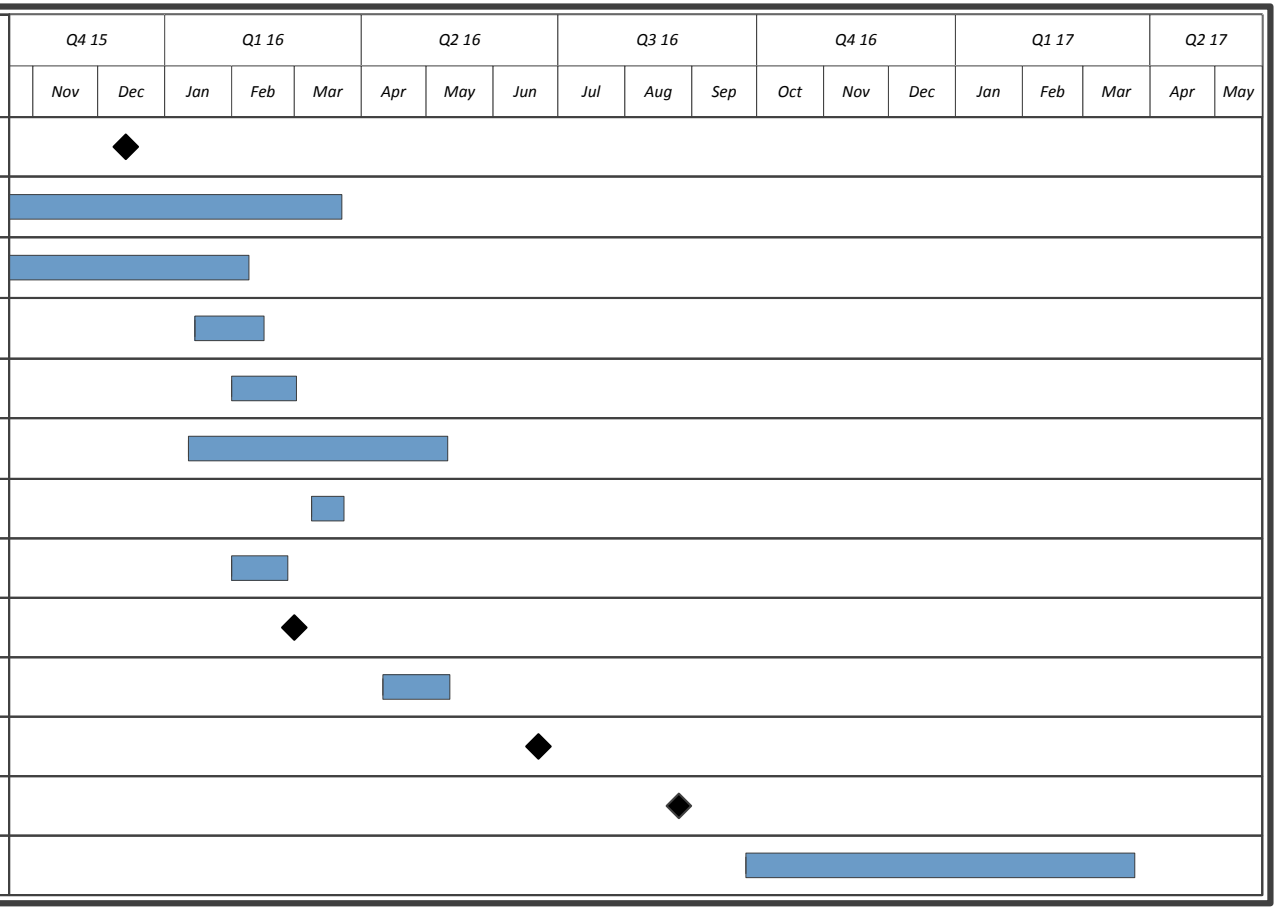
- **Advance Exploration System (AES) Sponsoring office**
- **RadWorks: JSC Lead**
  - JSC: charged particle sensors
  - LaRC: storm shelter and modeling
  - MSFC: neutron sensor
- **Spiral I: ANS Objectives (2012-2014)**
  - Develop neutron spectrometer for exploration missions
  - Year1: design, test and demonstrated 1st generation
  - Year2: critical comparison with state of the art techniques
  - Year3: 2nd generation design: 2.3 kg, 4W
- **Spiral II: ANS Objectives (2015-2017)**
  - ISS test flight demonstration
  - Year1/2: design, fabricate and test ANS-ISS
  - Year2: deploy to ISS
  - Year3: operate and acquire data for analysis
- **Spiral III: Operational for Manned Exploration (2018+)**

Radiation Environment

- Radiation risk to crew includes charged particles and neutral particle (neutrons and gamma/x-ray)
- Sources of charged particles in LEO include: GCR, SEP, trapped particles
- Neutrons are generated through the interaction of the charged particles with any mass: spacecraft/habitats and planetary surface or atmosphere (e.g. albedo from Earth's atmosphere)

Milestones

ID	Task Name	Start
1	Beam test (Germany)	12/14/2015
2	Electronics Fabrication & Test	10/21/2015
3	Mechanical Fabrication	10/21/2015
4	EM Assembly & Test	1/15/2016
5	FM Assembly & Test	2/1/2016
6	Test & Verifications	1/12/2016
7	EMI Test (MSFC)	3/9/2016
8	Software laptop certification testing	2/1/2016
9	Software Delivery	3/1/2016
10	Verification Submittal	4/11/2016
11	Hardware Delivery to JSC	6/22/2016
12	Launch	8/26/2016
13	Operations	9/26/2016



Payload Team

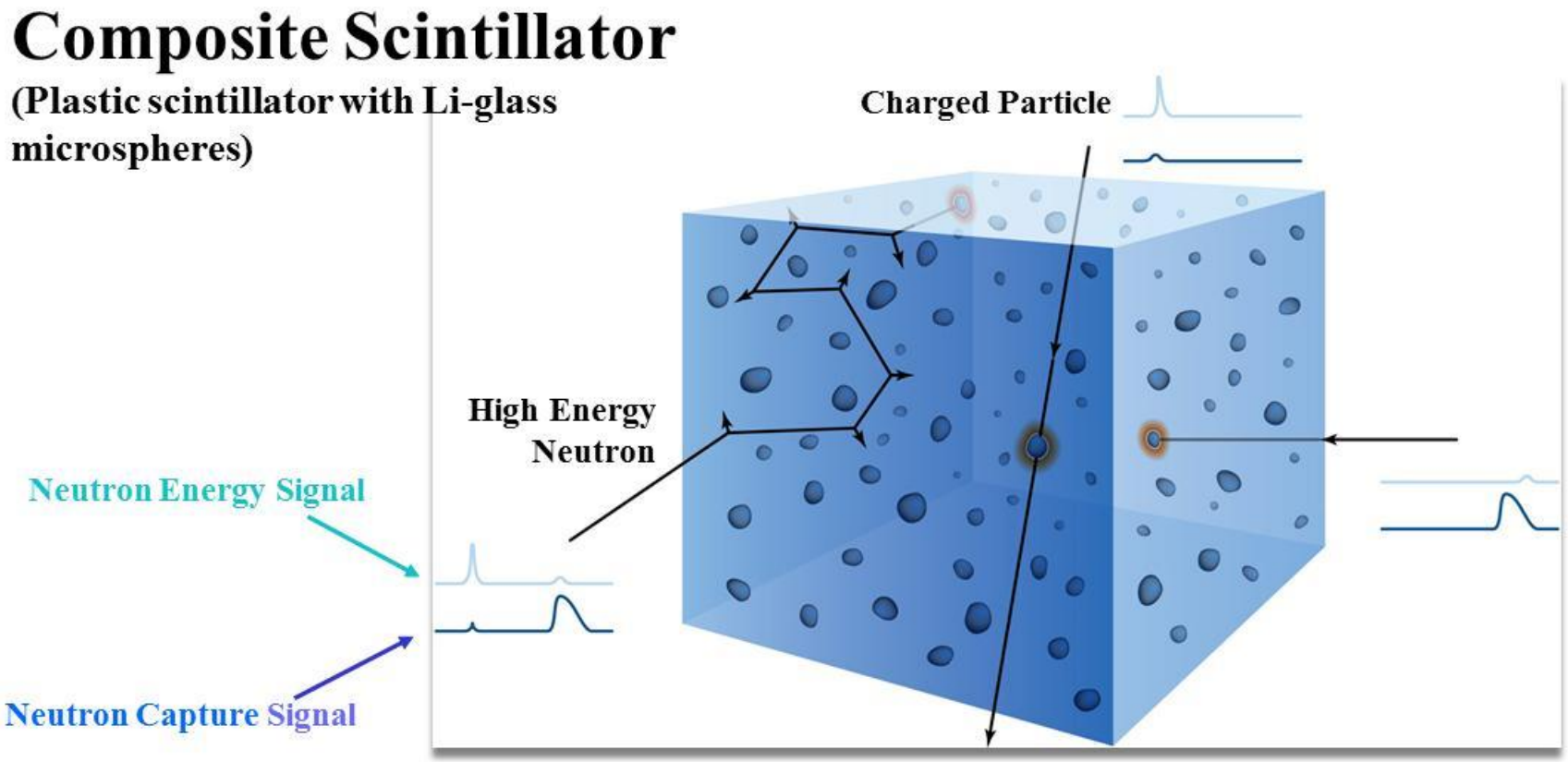
Name	Org	Role
Mark Christl	ZP12	PI
Mohammad Sabra	USRA	Simulations
Joey Norwood	EM50	Simulations
Chris Dobson	ER24	Simulations
John Watts	UAH	Simulations
Jeff Apple	ES63	LE
Carl Benson	ES63	Test
Kurt Dietz	ES63	Software
Michele Foster	ES13	System/OPS
Brian Gibson	ES36	FPGA
Doug Huie	UAH	Tech
Terry Jones	QD22	S&MA

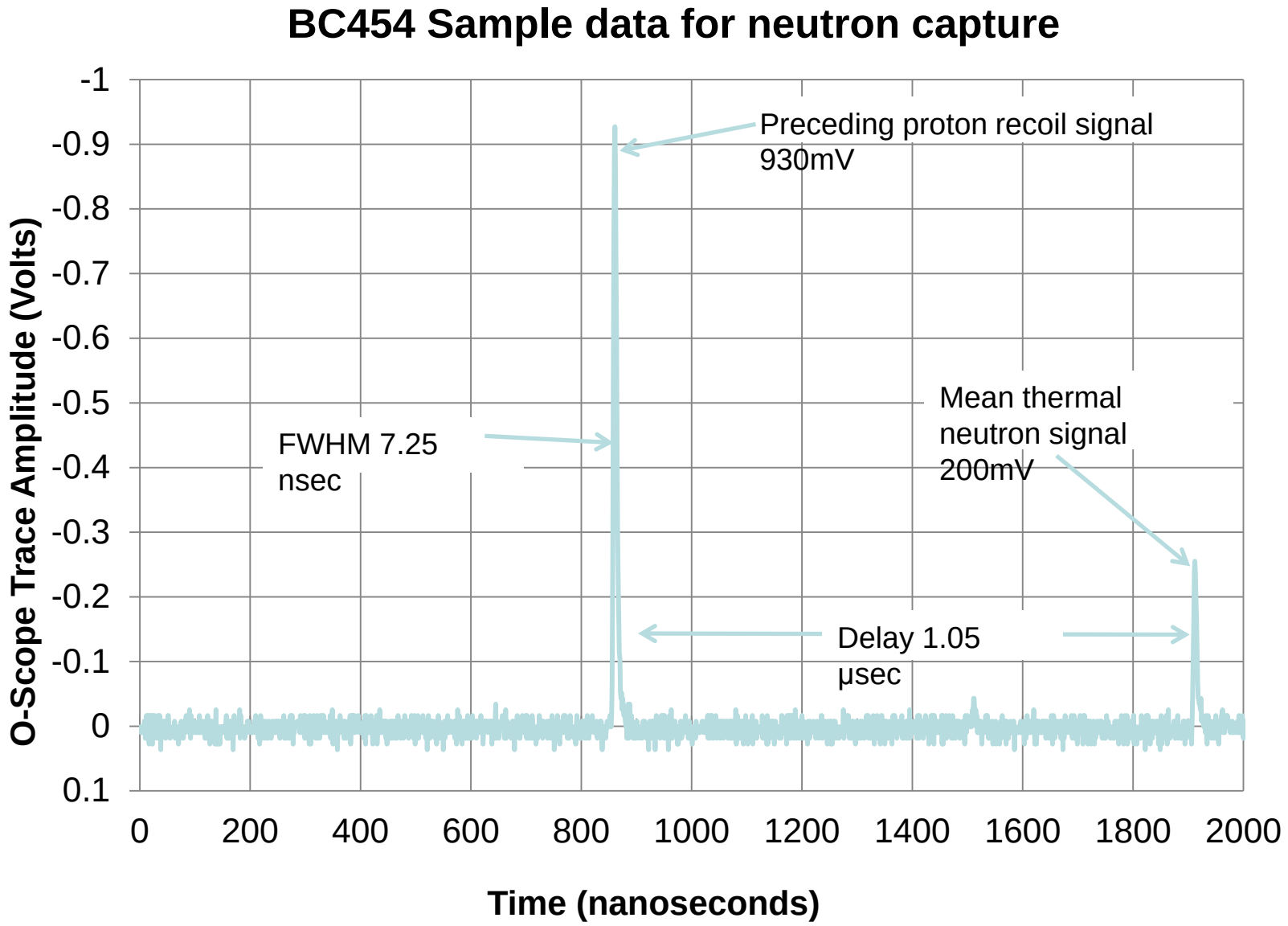
Name	Org	Role
Evgeny Kuznetsov	UAH	Analog
Garrick Merrill	ES36	Layout
Donna Prsha	ES11	SE
Miguel Rodriguez	ES36	Power
Dennis Smith	ES36	DC/DC
Keary Smith	ES36	DC/DC
Gary Thornton	ES36	Mechanical

Name	Org	Role
Catherine Mcleod	JSC	PM
Eddie Semones	JSC	Technical

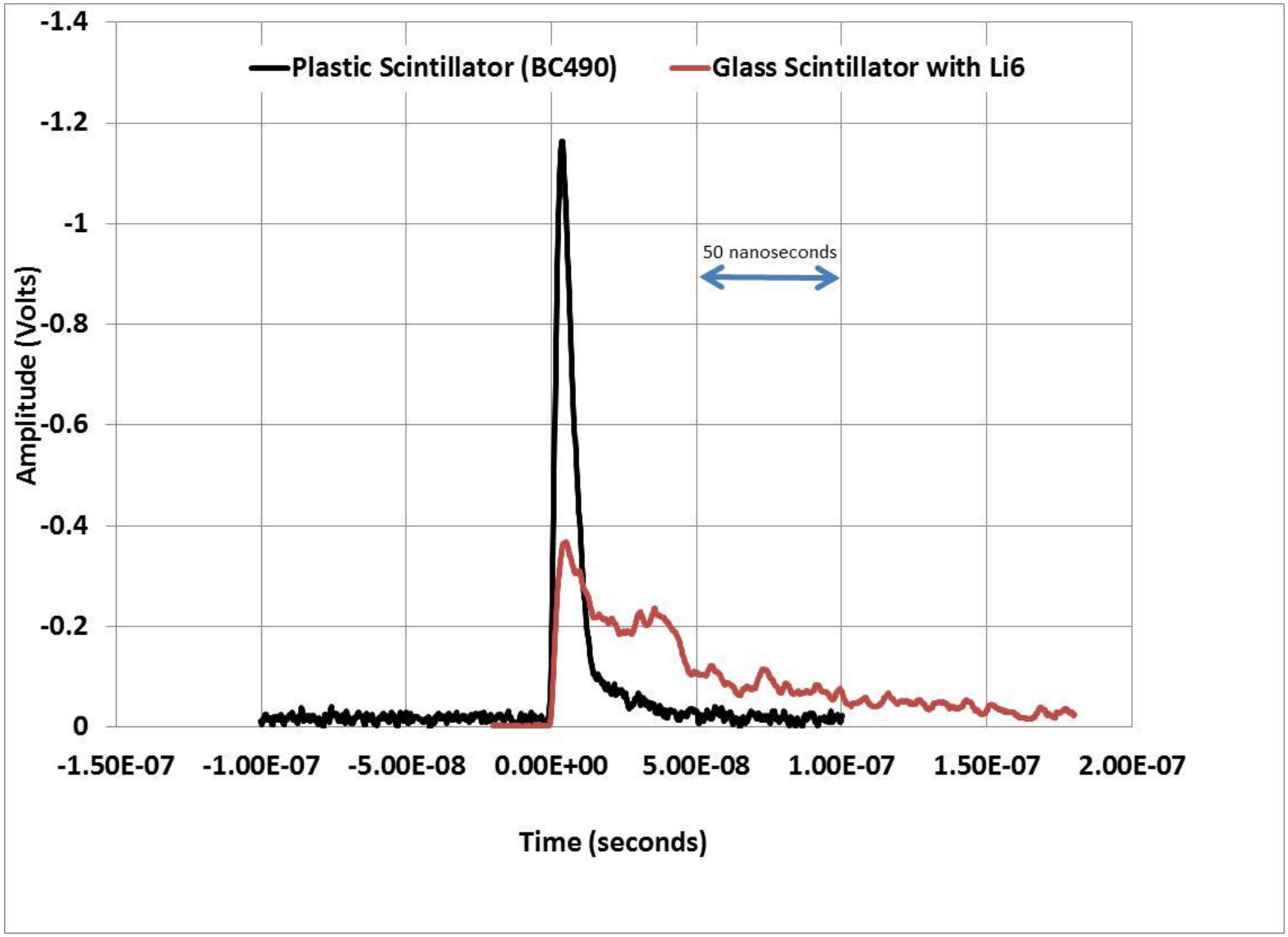
FNS Detection Technique

Gate and Capture Technique for neutrons




BC454 Sample data for neutron capture
O-Scope Trace Amplitude (Volts)
-1
-0.9
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Time (nanoseconds)
Preceding proton recoil signal
930mV
FWHM 7.25
nsec
Mean thermal
neutron signal
200mV
Delay 1.05
µsec

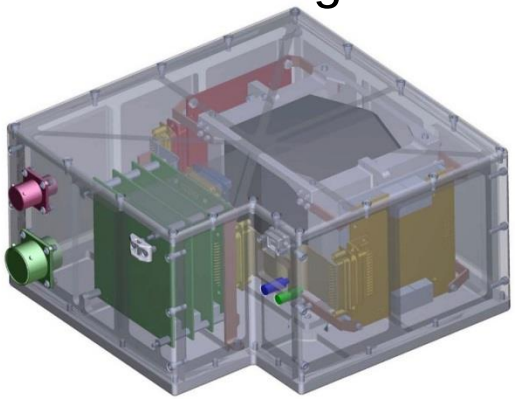
Comparison of Scintillation Signal in plastic and Li-6 glass



FNS Summary

Objectives

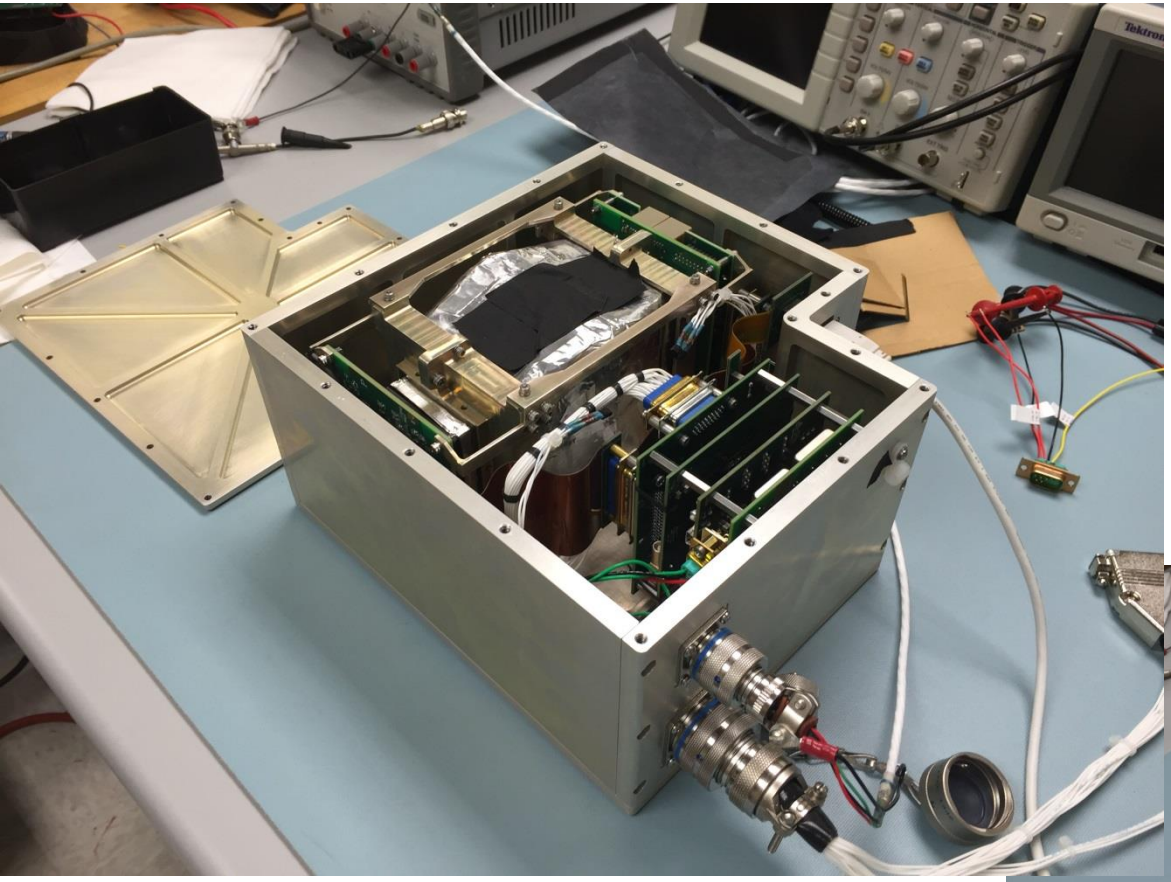
- The ISS provides a relevant spaceflight environment for testing hardware
- Mature the ANS measurement technique and design
- Deploy to ISS for >6 month mission
- Transmit data to ground for analysis
- Analyze data to determine the fast neutron spectrum on the ISS
- Compare with FND
- Evaluate environment background

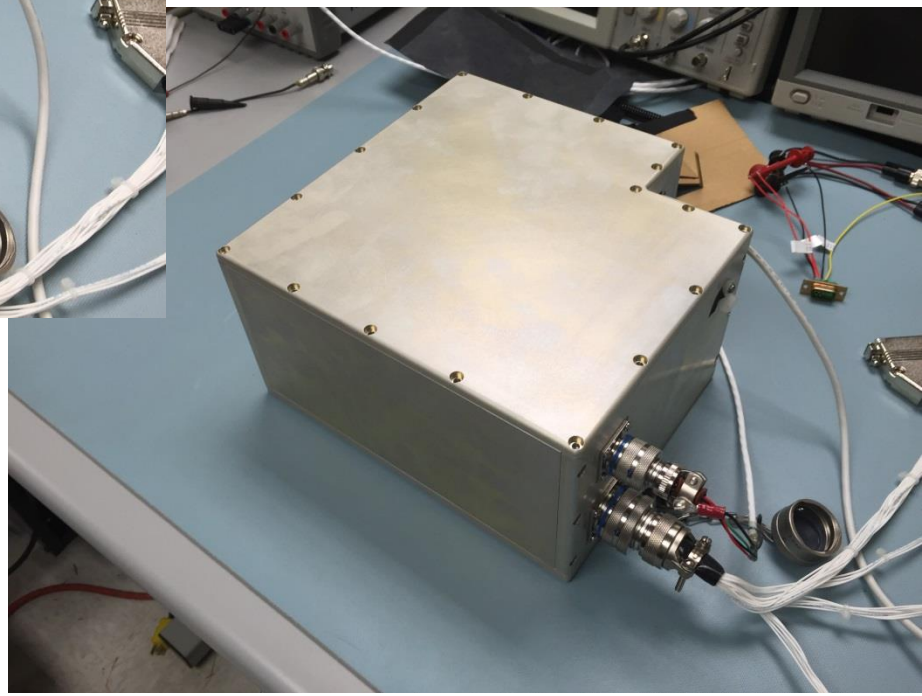


Allocation

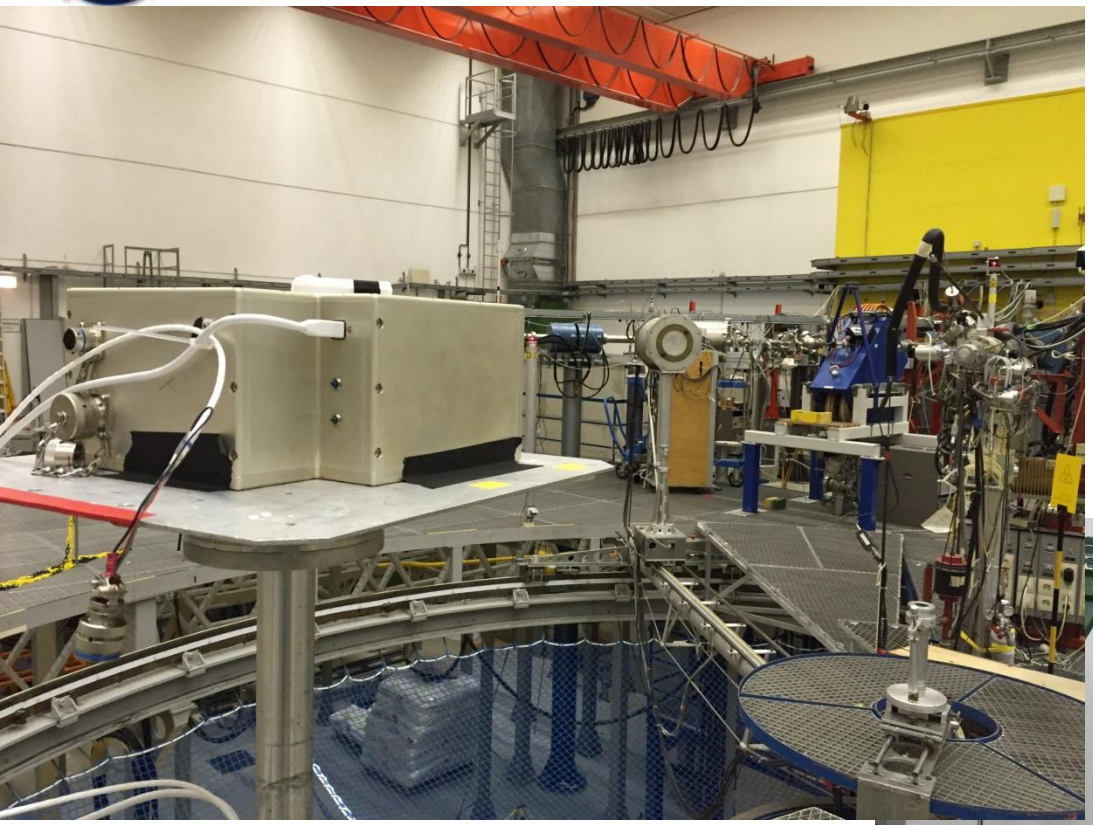
- Mass: 4.9 kgs
- Volume: 5.2”x9.6”x10”
- Power: <7.5 W
- Voltage: 28 VDC
- Data Link: USB to ISS laptop
- Data Rate: 100 kbits/sec
- Attachment location: Internal
- Attachment method: Velcro
- Mission
  - Primary: 6 months
  - Secondary: ISS duration
- Launch configuration: Soft stow
- Payload readiness date: June/July2016

Engineering Detector for Calibration





EM Calibration Germany Dec 2015



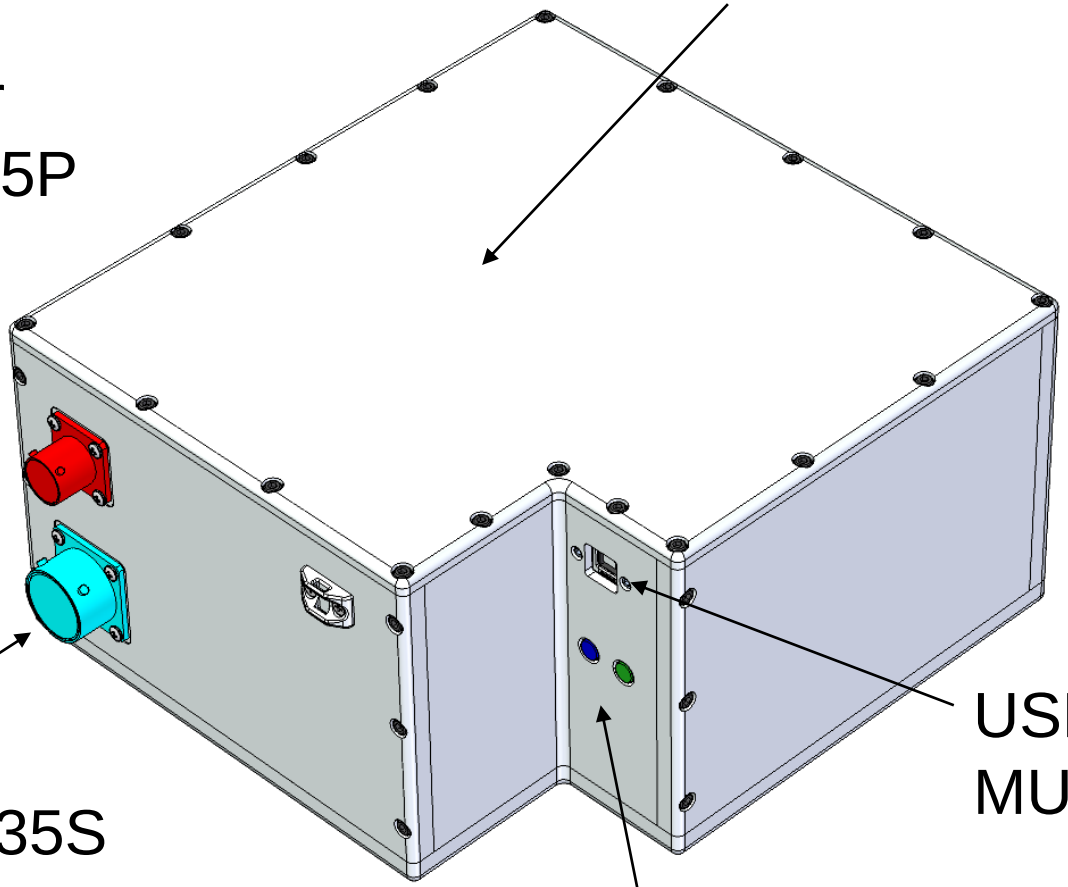
Source Spectra:
AmBe 4-8 MeV
Cf 0-1.2 MeV

Neutron Energies:
0.26, 0.57, 1.2 , 2.5
5, 8 & 14.8 MeV

FNS Assembly & Interfaces

Velcro attach point top/ bottom
Enclosure 6061-T6 Al
Fasteners 300 Cres SS

28 VDC Power
MS27466T11F5P



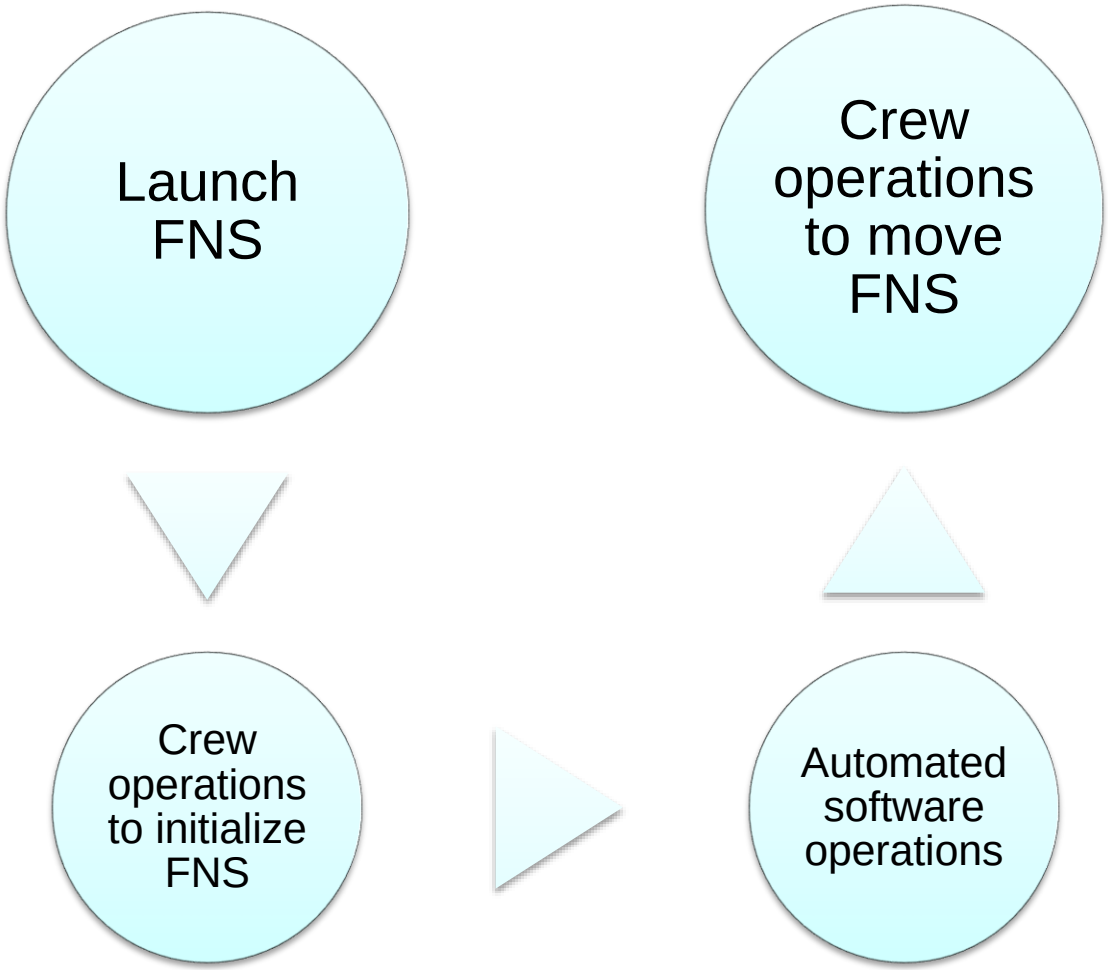
GSE I/O
MS27466T17F35S

USB 2.0 Type B
MUSB-D111-30

LEDs
Blue = data transferring
Green = power on

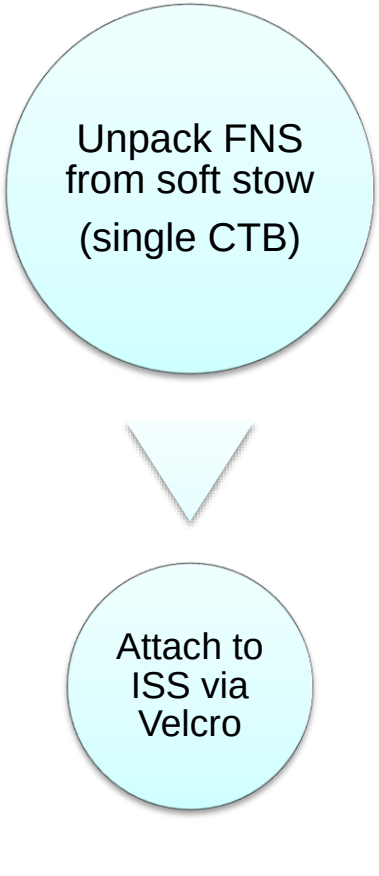
Overall envelope 10.0” x 9.6” x 5.2”
Mass 10.8 lbs

Fast Neutron Spectrometer Operations



Iterative process repeated at
Multiple ISS locations in U.S. Segment

Crew Operations



- GREEN LED ON = FNS power is ON
- BLUE LED ON = FNS data transfer to laptop in progress (do not unplug USB cable)

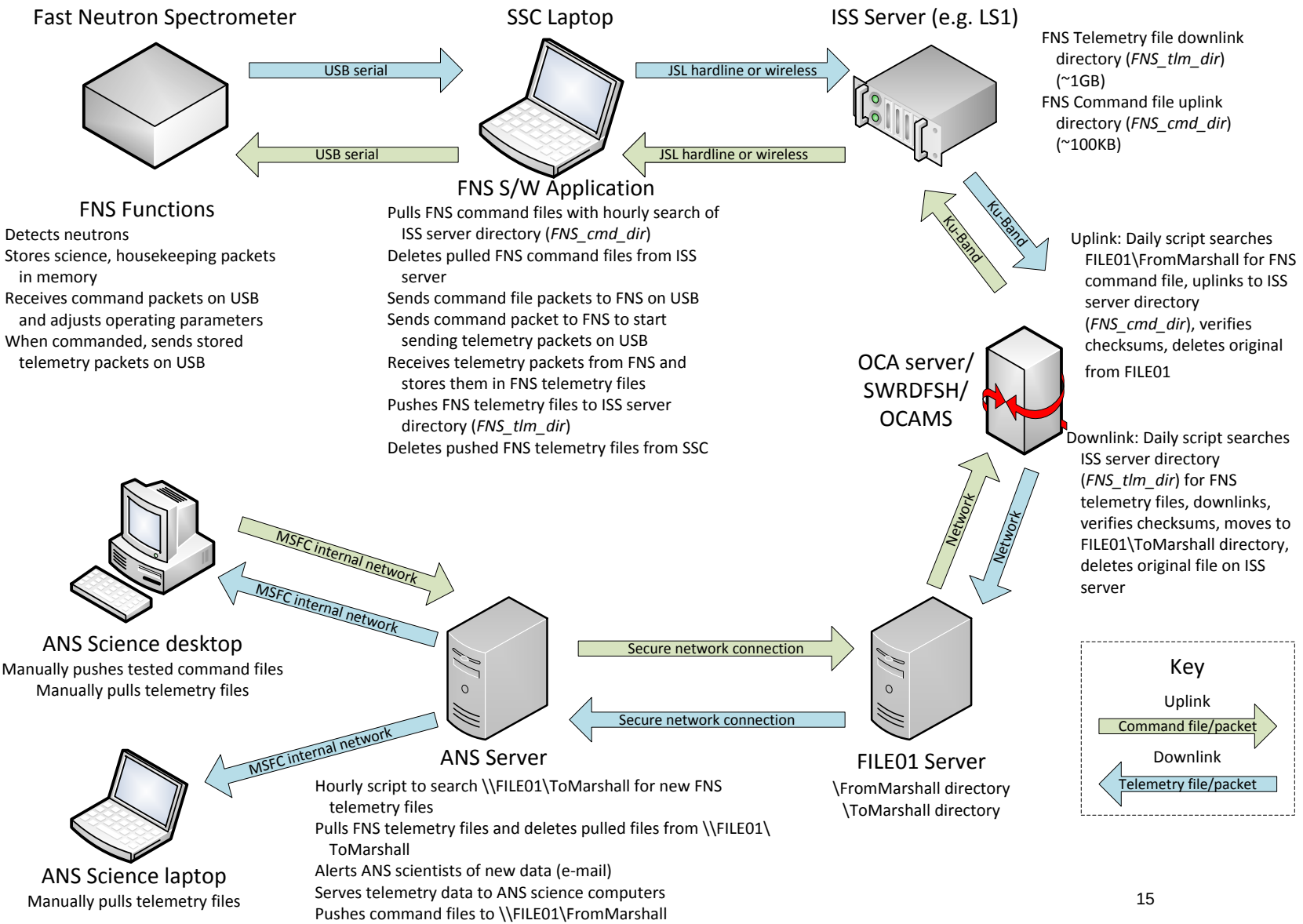
Preferred Configuration Plugged into SSC

- FNS will continue operations and store data to internal memory
- FNS software will transfer data to laptop once per day

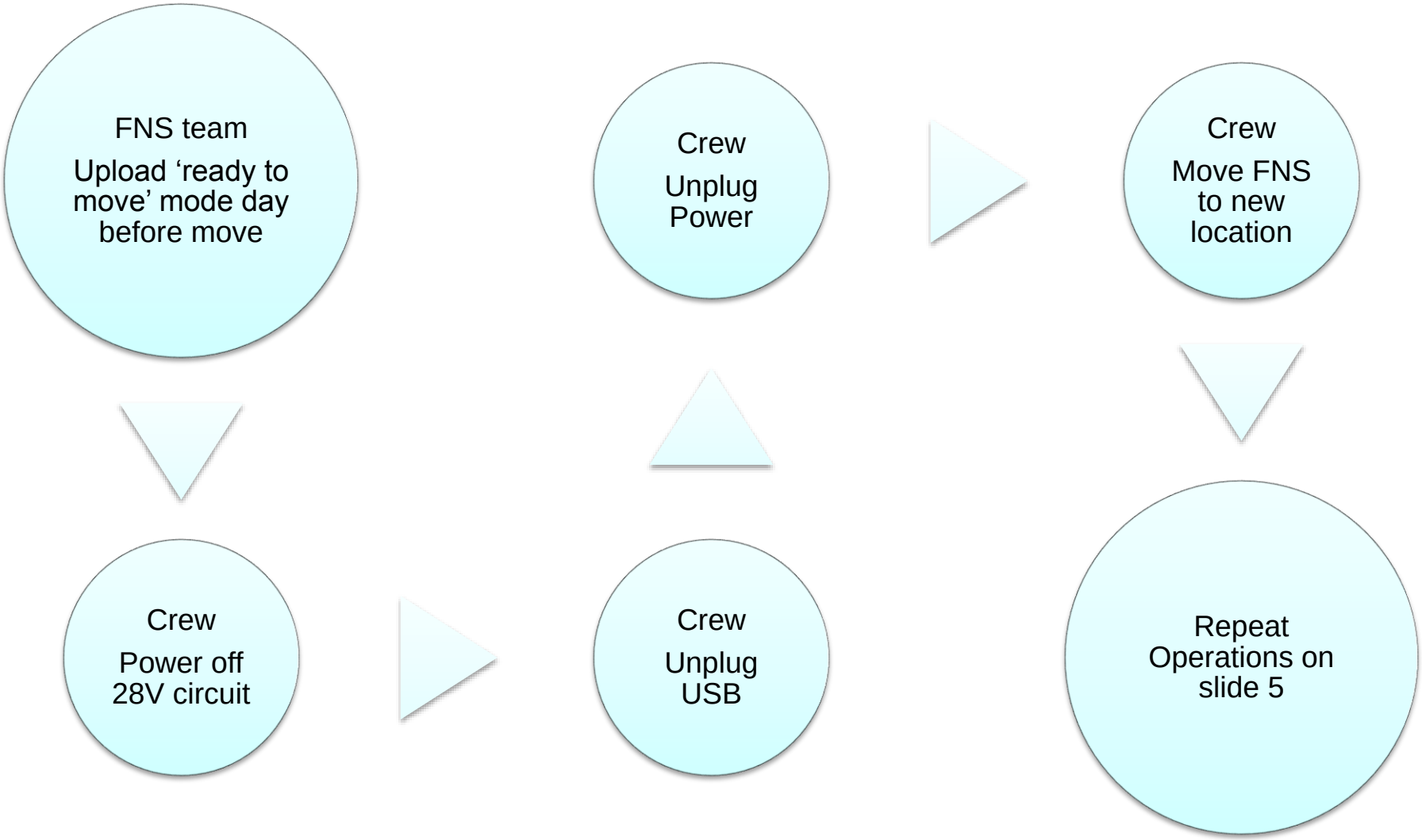
Unplugged from SSC

- FNS will continue operations and store data to internal memory
- Crew must connect FNS to laptop within 3 (TBC) days

FNS Data Path



Crew Operations to Move FNS (Locations TBD)



- FNS must be moved near a SSC laptop in the U.S. Segment
- FNS will be moved 2 times over six months.

FNS SSC Application basics

(FNS detector has no software)

1. **Starts automatically at SSC power-up (as a service)**
2. **Runs without human intervention for as long as the SSC is powered**
3. **Detects connection of FNS hardware, and immediately and at periodic intervals:**
   - Sends commands to establish connection and set time on FNS hardware
   - Moves any existing command files from ISS flight server to SSC
   - Uploads command files from SSC to FNS
   - Sends command to begin downlinking telemetry from FNS
   - Receives telemetry from FNS and store it on SSC laptop until termination telemetry packet, disconnection, or telemetry timeout.
   - Moves telemetry files from SSC to ISS flight server
4. **Detects disconnection of ANS-ISS hardware, stops all communications and threads, and ceases all activities above except (perhaps) the last.**